8/2003

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US-PAT-NO: 6346184

DOCUMENT-IDENTIFIER: US 6346184 B1

TITLE: Method of producing zinc oxide thin film, method of producing photovoltaic device and method of producing semiconductor device

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US Patent No. - PN (1):
6346184

claim 49 like allowed claim 5





outdoor exposure test, a HH (high temperature high humidity) test and long-term light irradiation. Further, the cost of the photovoltaic device can significantly be decreased. Particularly, the power cost of a solar cell can be decreased.

While the present invention has been described with reference to what are presently considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. On the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

What is claimed is:

1. A method of producing a zinc oxide film comprising passing a current between a conductive substrate immersed in an aqueous solution consisting essentially of carboxylic acid ions and zinc ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

2. A method of producing a zinc oxide thin film according to claim 1, wherein the aqueous solution is an aqueous solution of zinc acetate.

3. A method of producing a zinc oxide thin film according to claim 1, wherein the aqueous solution is an aqueous solution of zinc formate.

4. A method of producing a zinc oxide thin film according to claim 1, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

5. A method of producing a zinc oxide thin film according to claim 1, wherein a hydrogen ion concentration of the aqueous solution is controlled in the range of pH 3.5 to pH 5.5.

6. A method of producing a photovoltaic device comprising the steps of:

forming a zinc oxide thin film on a conductive substrate immersed in an aqueous solution consisting essentially of carboxylic acid ions and zinc ions by passing a current between the conductive substrate and an electrode as an anode immersed in the aqueous solution; and

forming a semiconductor layer on the top of the zinc oxide thin film.

7. A method of producing a photovoltaic device according to claim 6, wherein the aqueous solution is an aqueous solution of zinc acetate.

8. A method of producing a photovoltaic device according to claim 6, wherein the aqueous solution is an aqueous solution of zinc formate.

9. A method of producing a photovoltaic device according to claim 6, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

10. A method of producing a photovoltaic device according to claim 6, wherein a hydrogen ion concentration of the aqueous solution is controlled in the range of pH 3.5 to pH 5.5.

11. A method of producing a semiconductor device substrate comprising passing a current between a conductive substrate immersed in an aqueous solution consisting essentially of carboxylic acid ions and zinc ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

12. A method of producing a semiconductor device substrate according to claim 11, wherein the aqueous solution is an aqueous solution of zinc acetate.

13. A method of producing a semiconductor device substrate according to claim 11, wherein the aqueous solution is an aqueous solution of zinc formate.

14. A method of producing a semiconductor device substrate according to claim 11, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

15. A method of producing a semiconductor device according to claim 11, wherein a hydrogen ion concentration of the aqueous solution is controlled in the range of pH 3.5 to pH 5.5.

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